



Segmentation of individual fibres in a uni-directional composite from 3D X-ray computed tomography data

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Segmentation of individual fibres in a uni-directional composite from 3D X-ray computed tomography data



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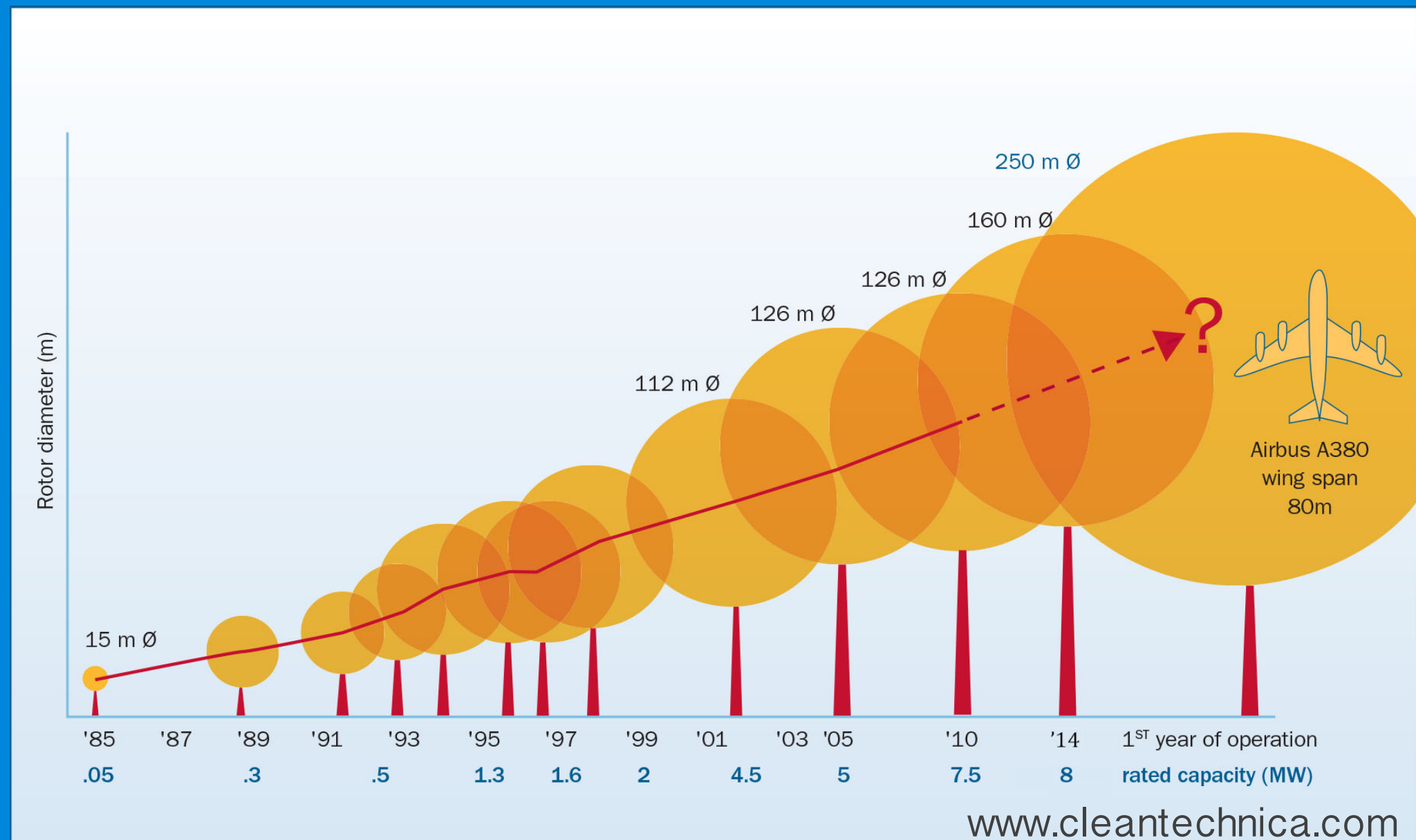
monj@dtu.dk

MOTIVATION

Wind turbine blades are becoming **longer** to decrease the **cost of energy**.



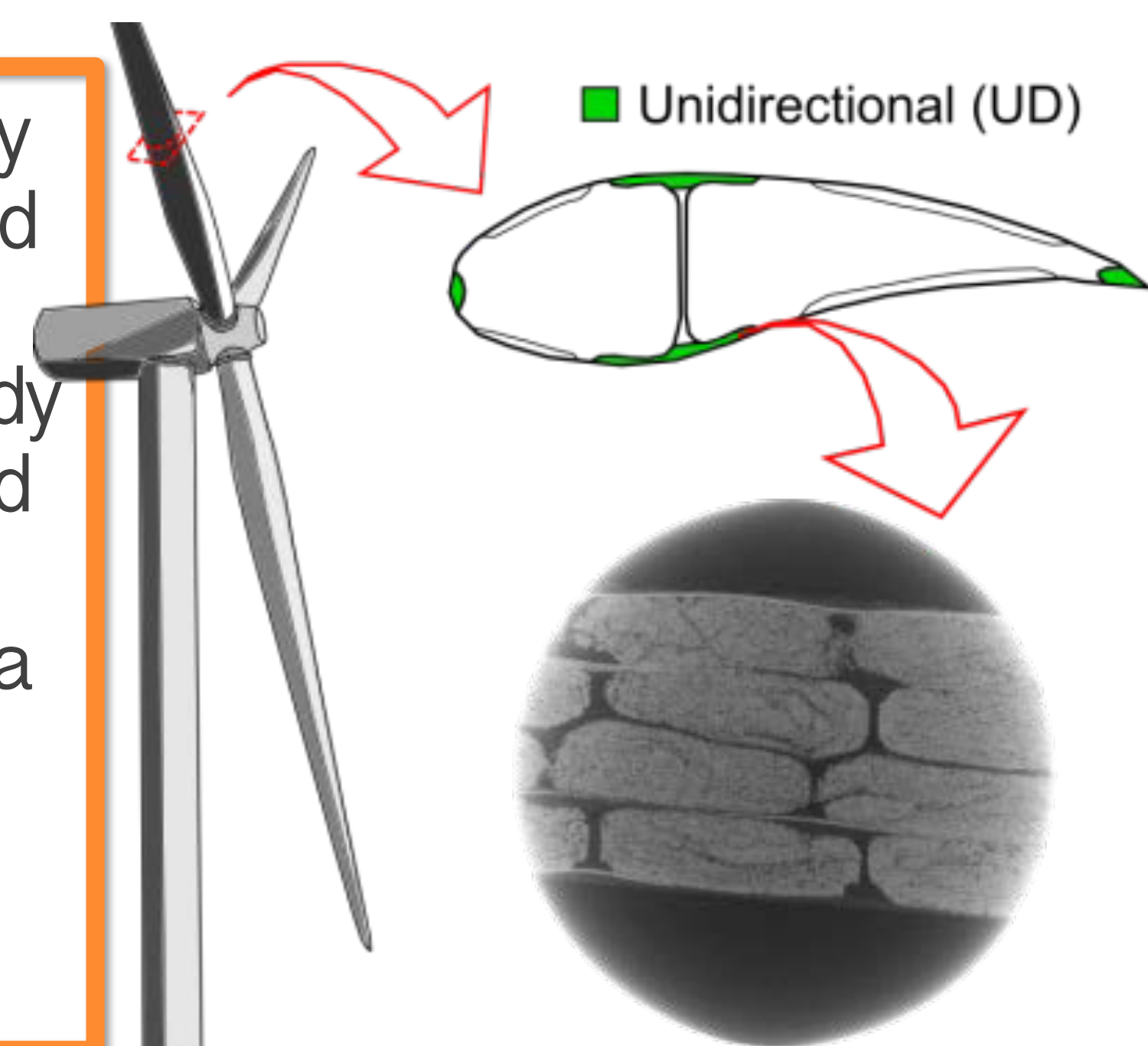
They need to stand higher stresses.



TASK

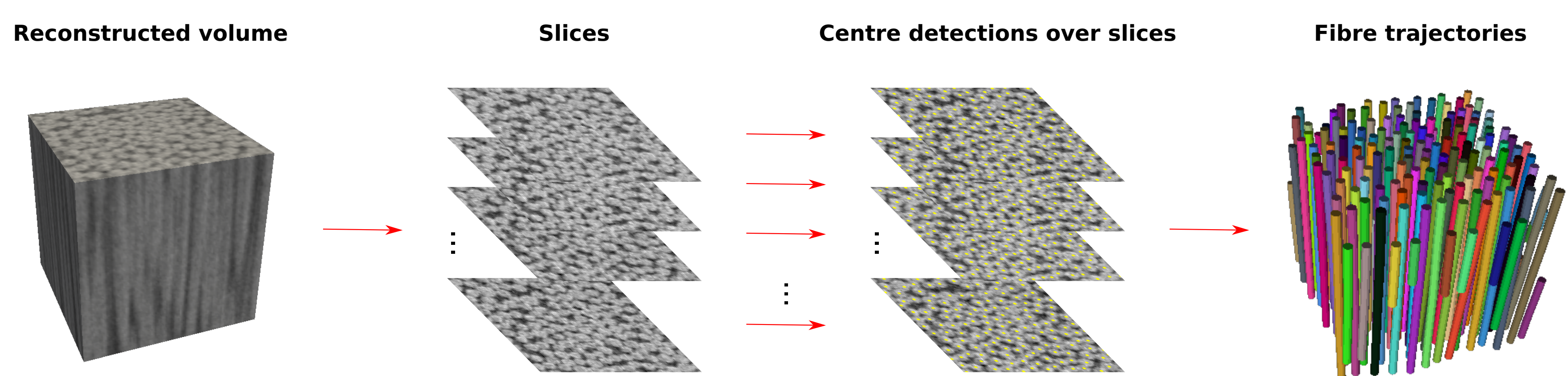
We segment individually uni-directional glass and carbon fibres from tomography data to study the **fibre orientation** and relate it to the **compression strength**, a key parameter when designing the blade's **load carrying parts***.

* green parts in the blade on the right



PIPELINE AND CHALLENGES

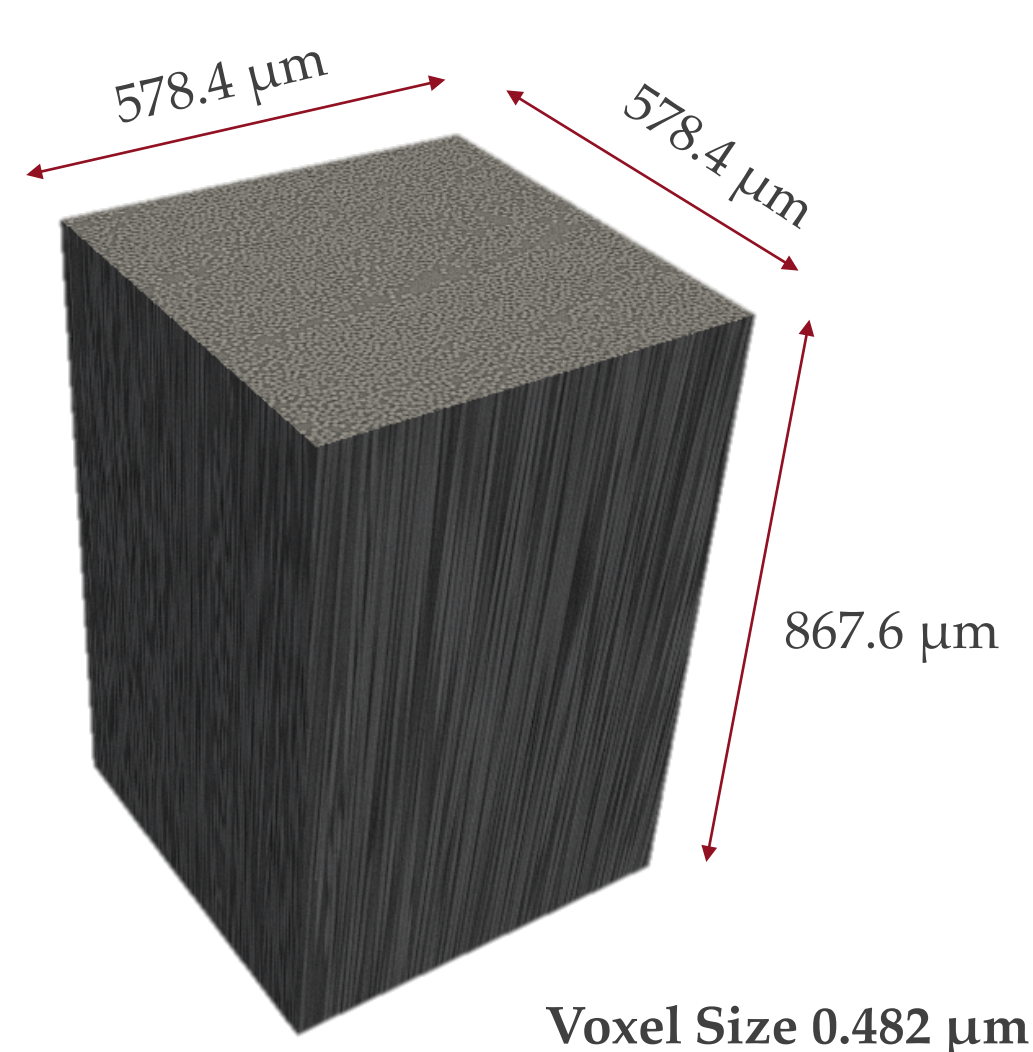
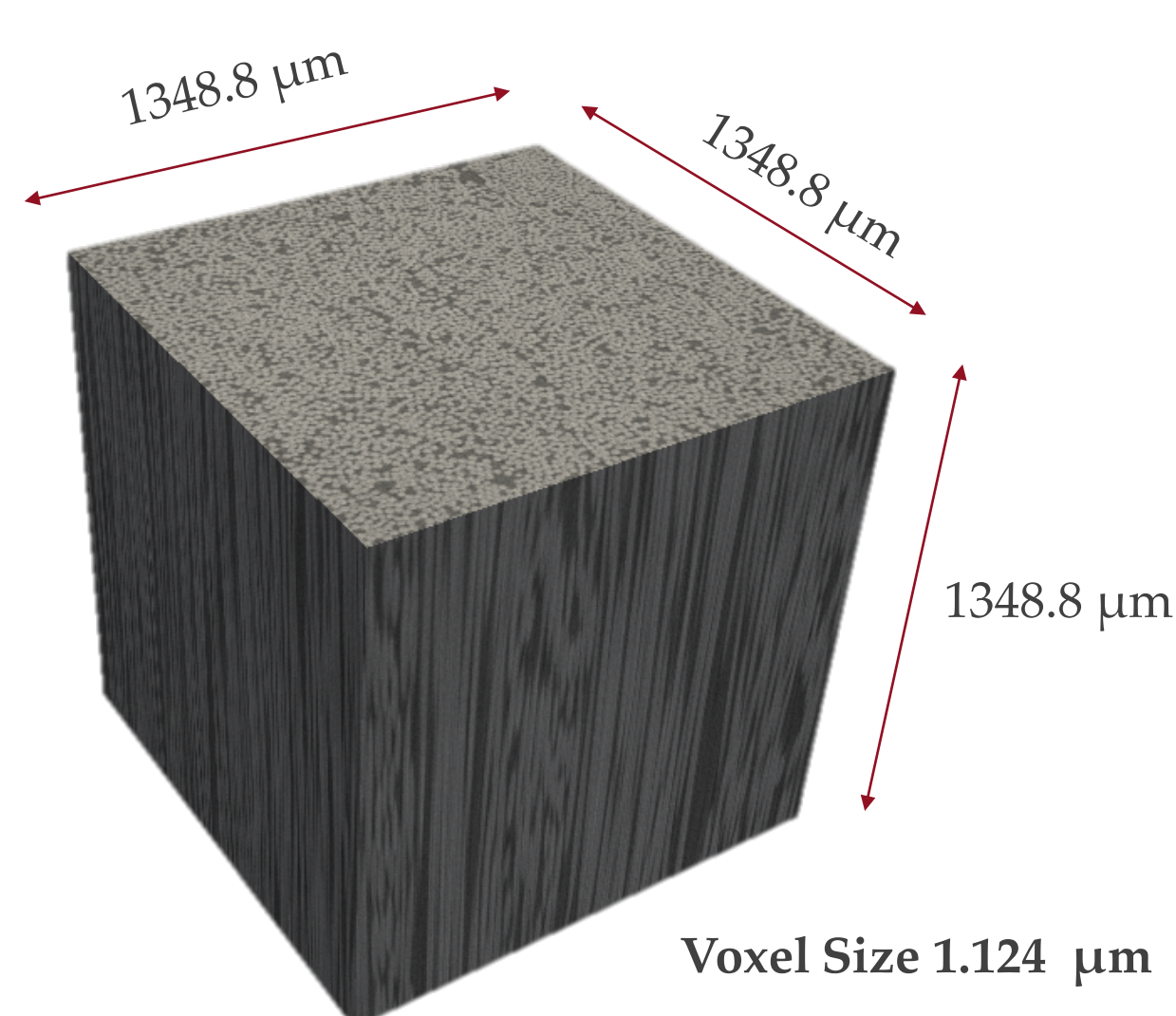
- Low quality scans to avoid a long acquisition time.
- Composite materials with high fibre volume fraction.
- Large data sets.



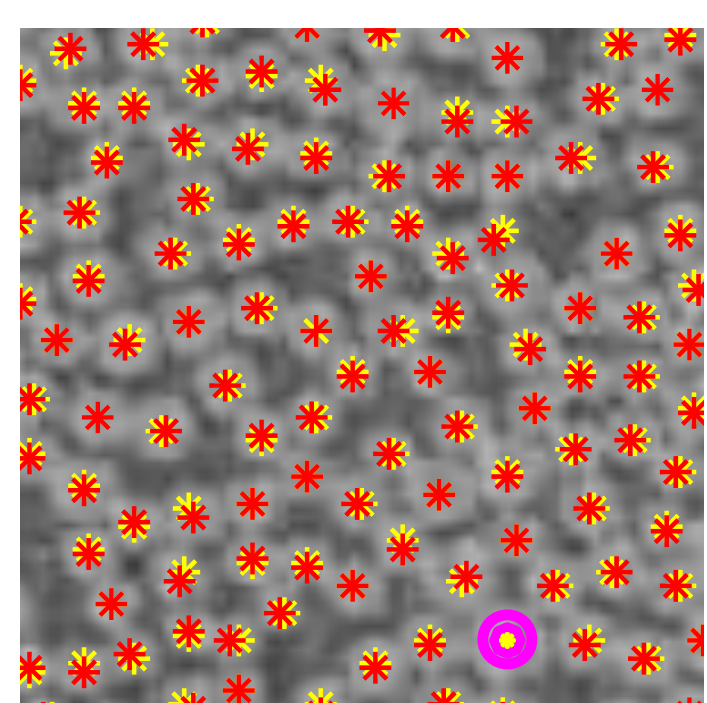
SEGMENTATION AND TRACKING

1. Glass Fibre Reinforced Polymer (GFRP)

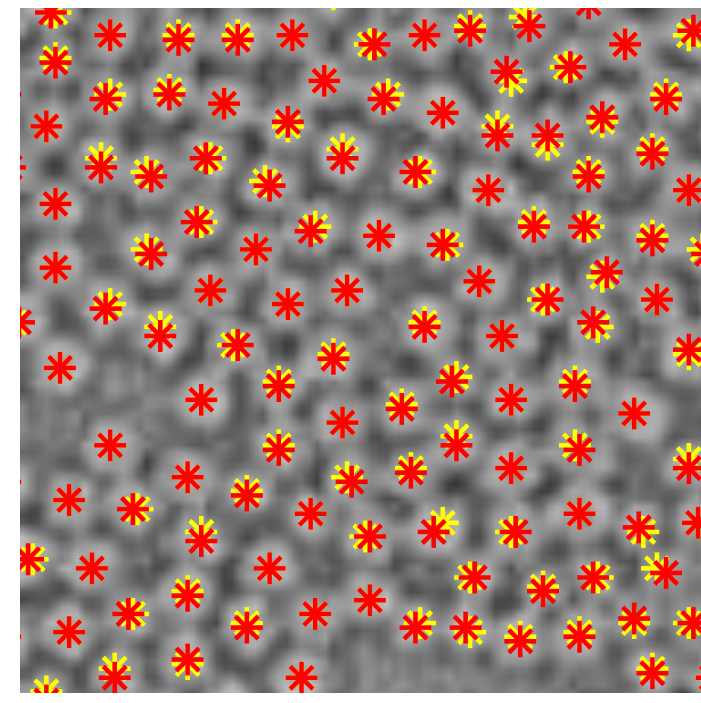
2. Carbon Fibre Reinforced Polymer (CFRP)



Detected centres in *red* and reference centres in *yellow*.



Accuracy** 99.1%

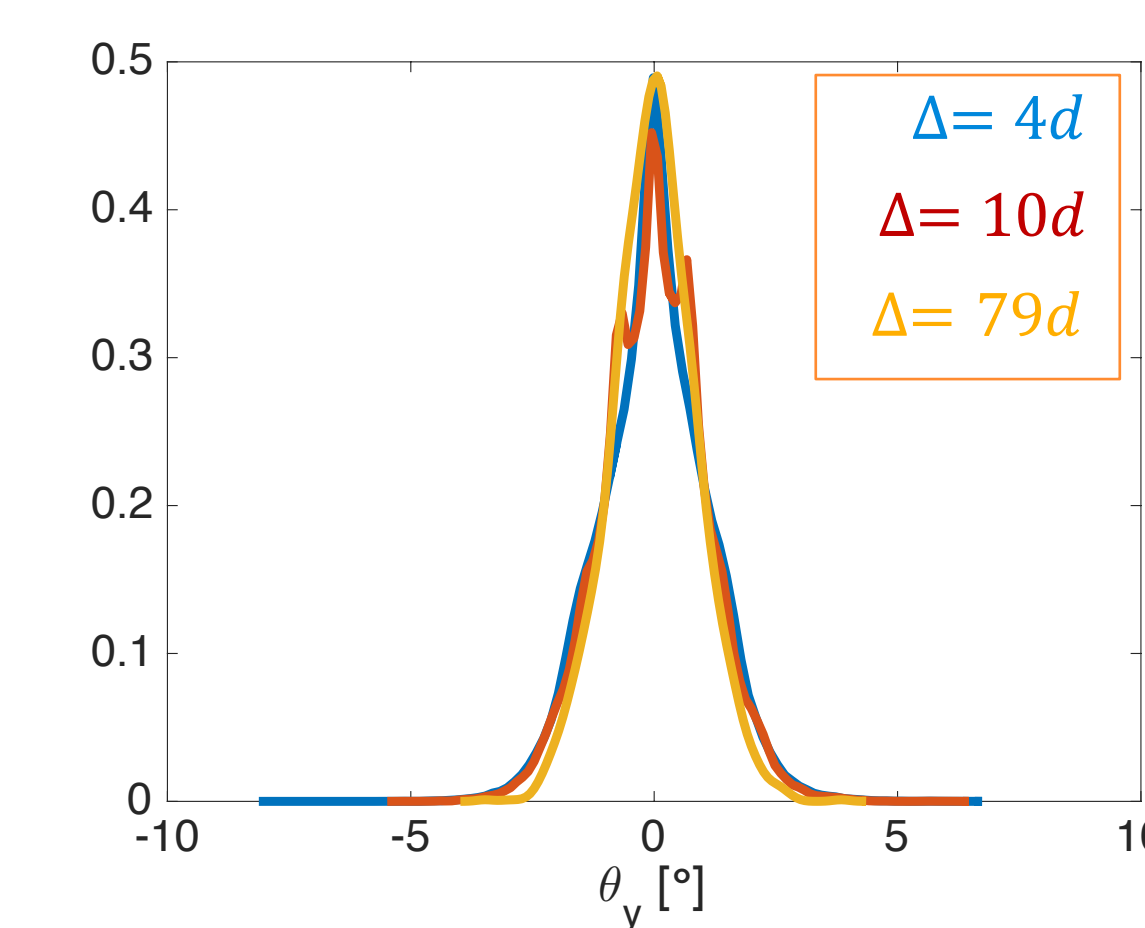
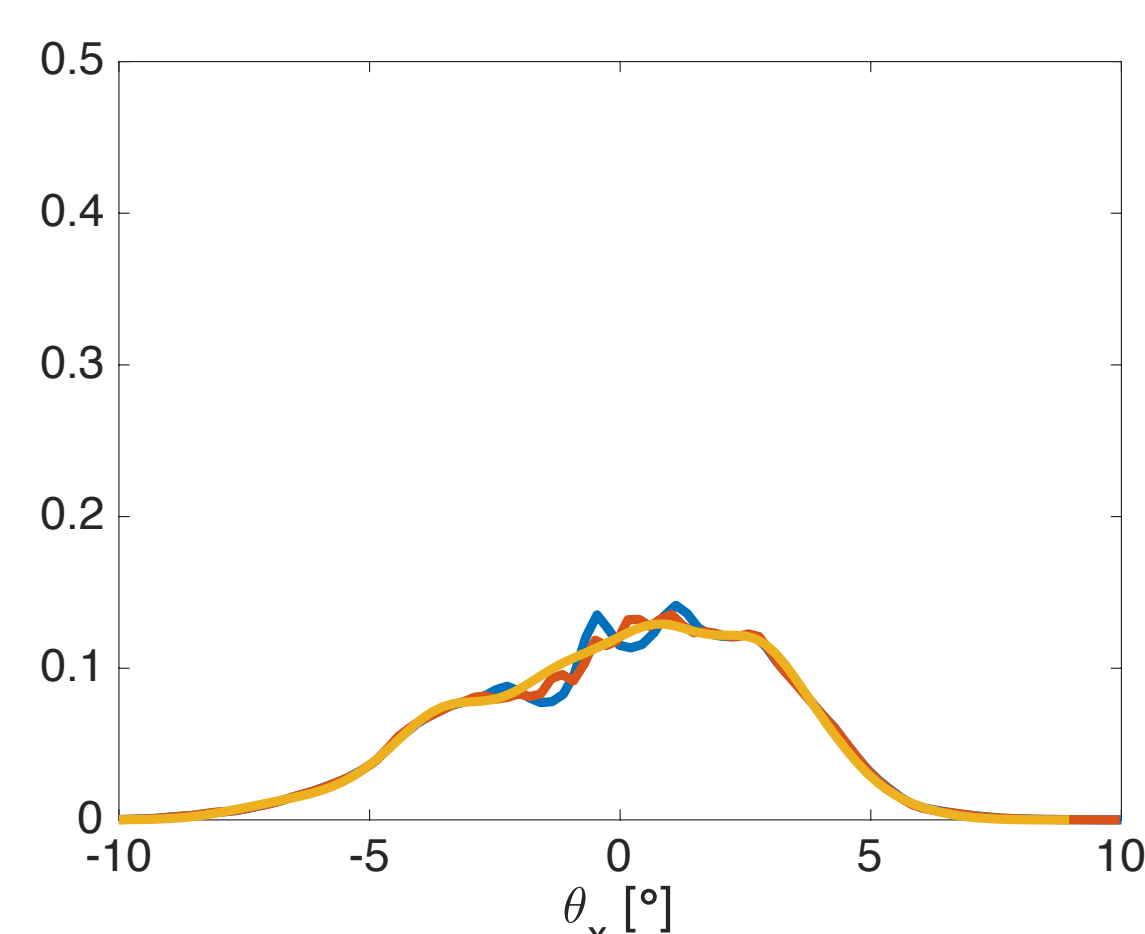


Accuracy** 100%

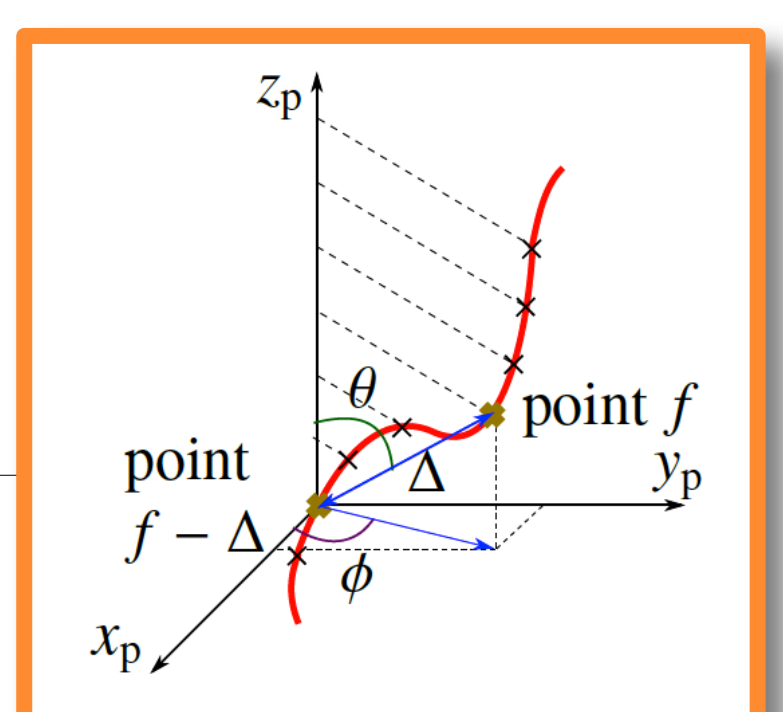
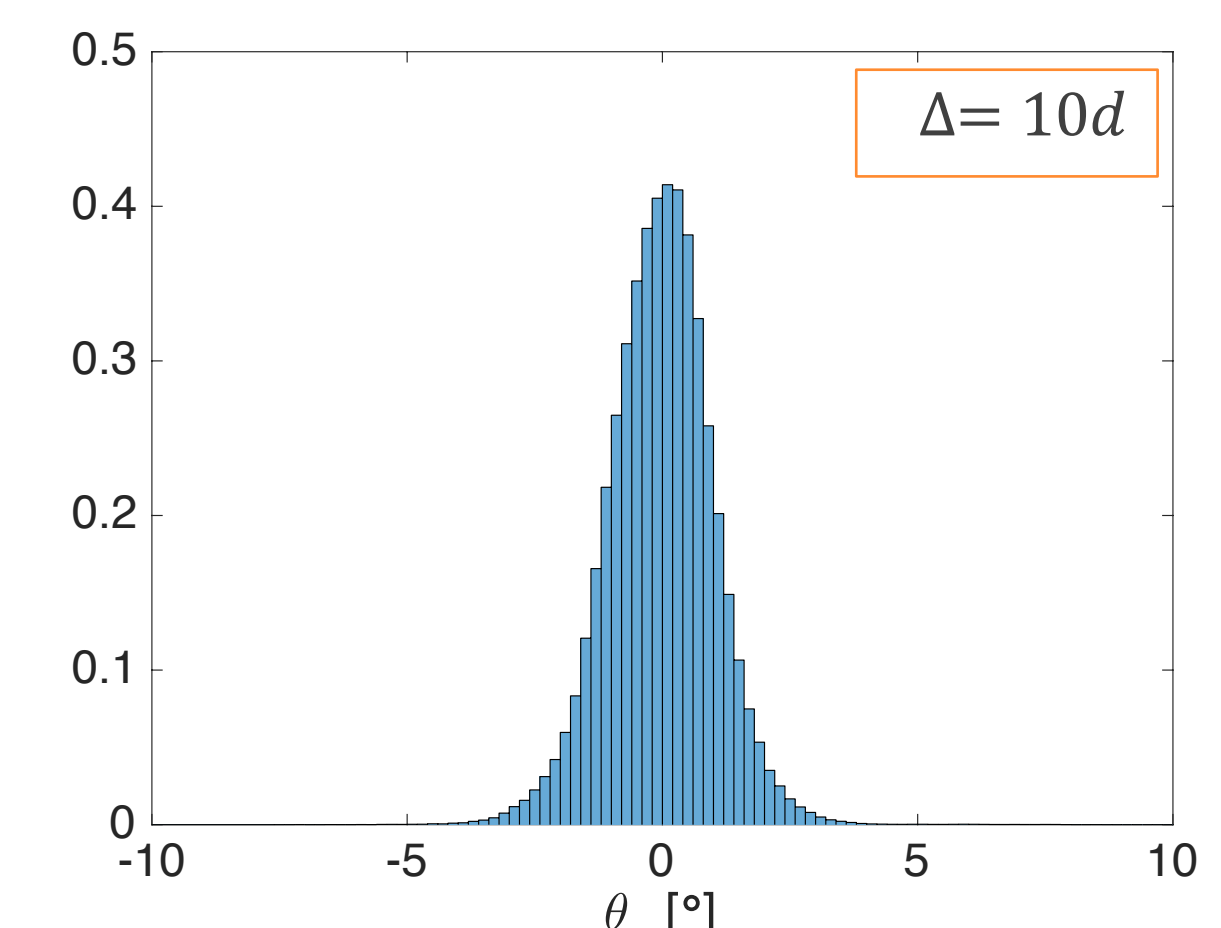
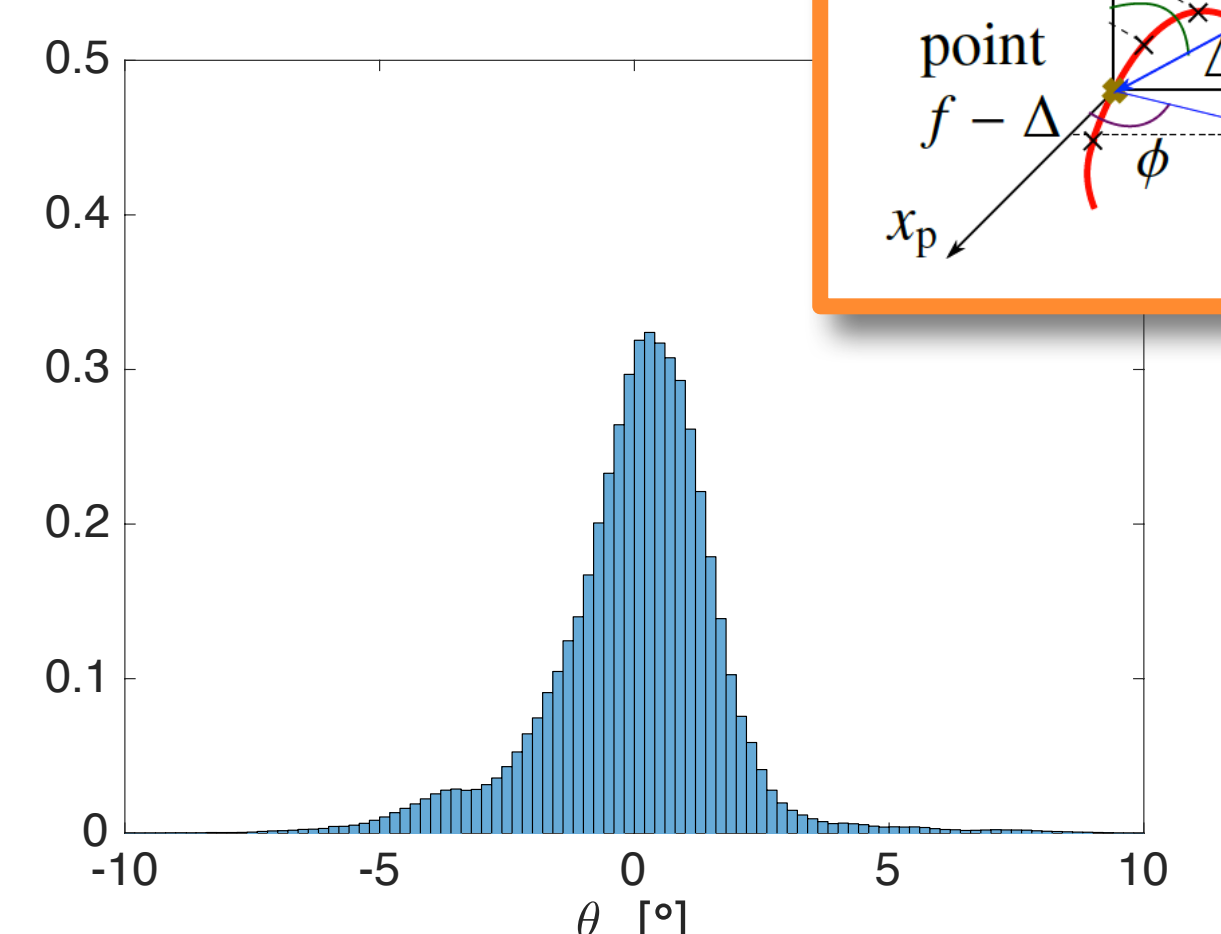
**Accuracy measured as correctly found centres in a test image, of size half of a slice.

FIBRE ORIENTATION

1. GFRP



2. CFRP



COMPRESSION STRENGTH

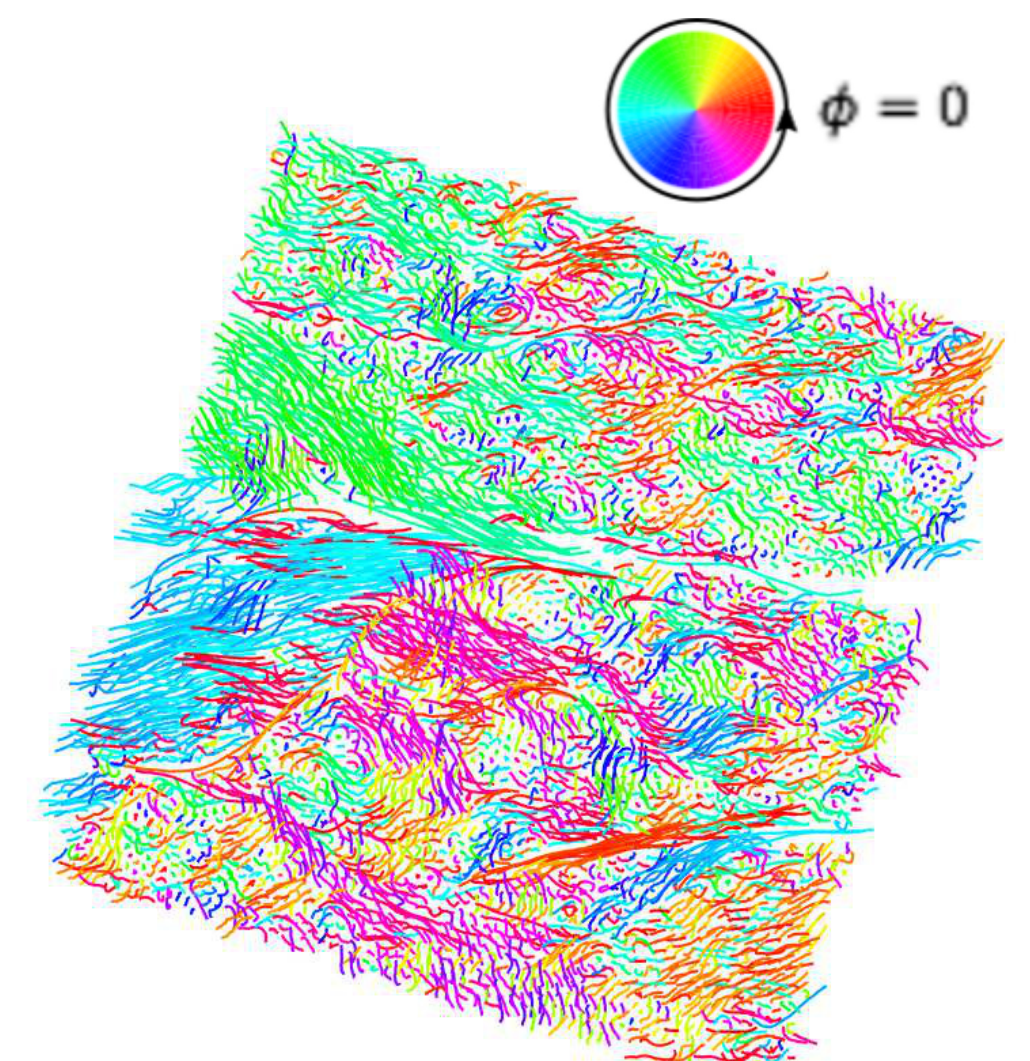
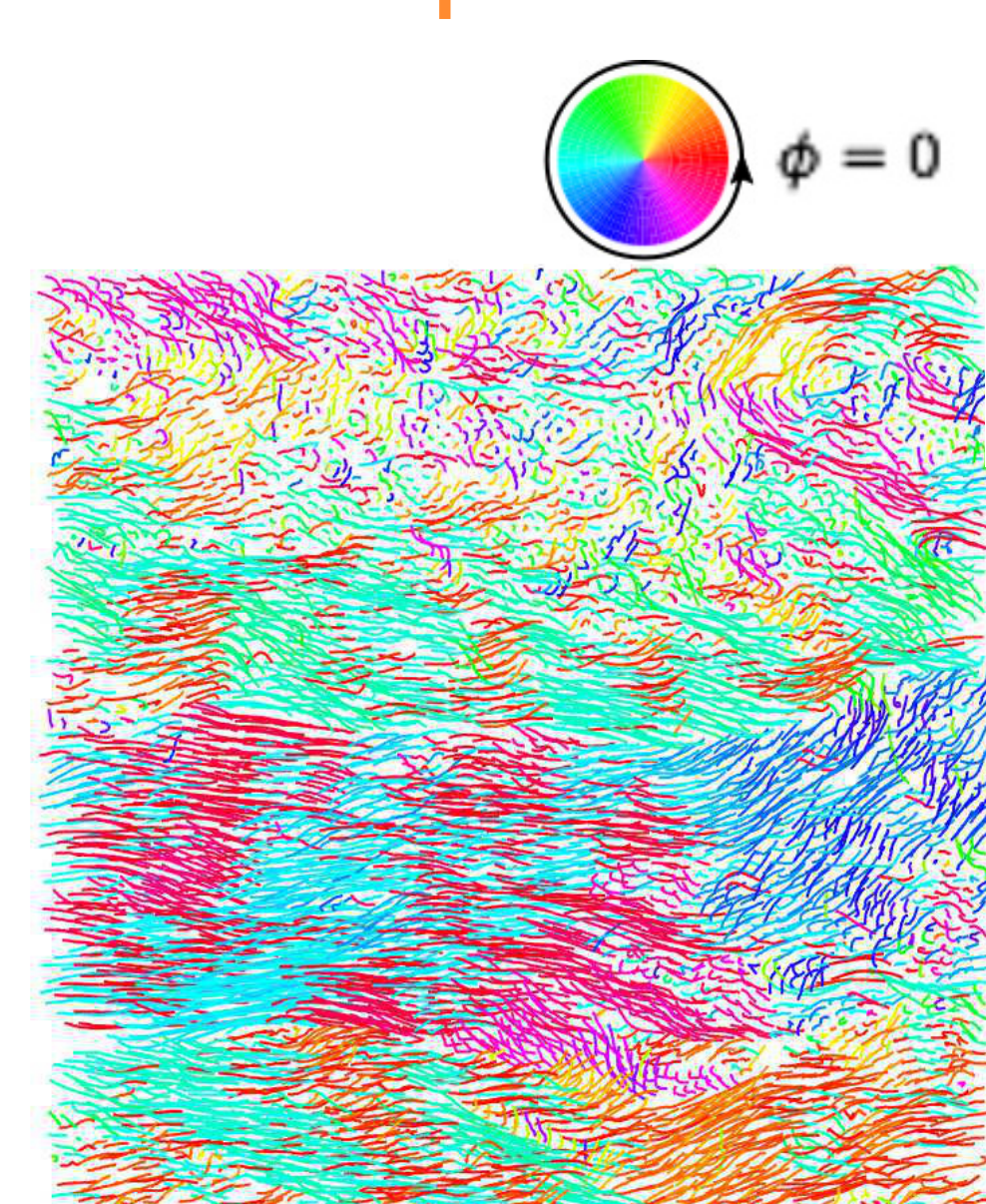
$$\hat{\sigma}_c = \frac{G}{1 + \hat{\theta}/\gamma_y}$$

(Budiansky et al., 1993)

Material	GFRP	CFRP
$\langle \theta \rangle$	2.75°	1.61°
$\langle \theta_x \rangle$	2.45°	1.23°
$\langle \theta_y \rangle$	0.86°	0.79°
$\hat{\sigma}$	0.44 GPa	0.70 GPa
$\hat{\sigma}_x$	0.49 GPa	0.87 GPa
$\hat{\sigma}_y$	1.14 GPa	1.21 GPa
σ_m	(0.82 ± 0.07) GPa	(0.90 ± 0.06) GPa

Estimated compression strength $\hat{\sigma}$ compared to measured σ_m by Markussen et al., 2013

For a more precise estimate...



...add the spatial distribution

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Individual fibre segmentation from 3D X-ray computed tomography for characterising the fibre orientation in unidirectional composite materials. Emerson et al., under submission.